The Efficacy of Standard Surgical Face Masks:

An Investigation Using "Tracer Particles"

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This article describes a study of particle emissions from the facial area of a surgeon wearing a popular, commercially available disposable cap and mask, made of soft synthetic fiber. Such masks are believed to be superior to gauze and paper masks, and it is believed they are an effective barrier to the transfer of bacteria from the face, mouth and upper respiratory tract into the surgical wound.[2-5,7] Bacteriologic studies have shown the inability of bacteria to penetrate such fabric. High filtration efficiency rates of more than 95% have been demonstrated in *in vitro* studies (Table 1).

Bacteria, however, may escape around the edges of the face mask (Fig. 1) and enter the wound.[5,6,8] Repeated use of face masks, coughing, sneezing, talking, and protracted operation may increase this possibility. By using human albumin microsphere "tracer particles," we have confirmed that this is a very real danger.

MATERIALS AND METHODS

A commercially available brand of surgical face mask made of fine glass-fiber mat sandwiched between 2 layers of nonwoven fabric (cellulose) was used for evaluation in our study.

The difficulty in tracing wound organisms by standard bacteriologic techniques led us to use human albumin microspheres (HAM) as "tracer particles." These particles are 10 to 35 μm in diameter and are supplied in a sterile powder form (185,000 $\pm$ 6,000 particles/mg) by the 3M Company (St. Paul, Minnesota). Being sterile and biodegradable, these particles are suitable for human experiments. In the operating room environment, bacteria are usually carried by particles and droplets of 5 to 30 μm in diameter.[1,9] Therefore, human albumin microspheres could substitute as an artificial contaminant in our experiments.

APPLICATION OF PARTICLES

A suspension of particles was prepared by adding sterile water to a vial of dry microspheres. A standard dose (0.5 mg/0.5 ml) was then sprayed with a syringe on the inner side and center of the face mask. The mask was left for a few minutes to dry and was then worn by the surgeon.

TABLE 1. Bacterial Filtration Efficiency

Report	*Average % of Efficiency*
Nicholes (1964)[1]	97.8
Ford *et al.* (1967)[3]	99.7
Madsen and Madsen (1967)[5]	98.1
Dineen (1971)[2]	96.0
Furuhashi (1978)[4]	98.7

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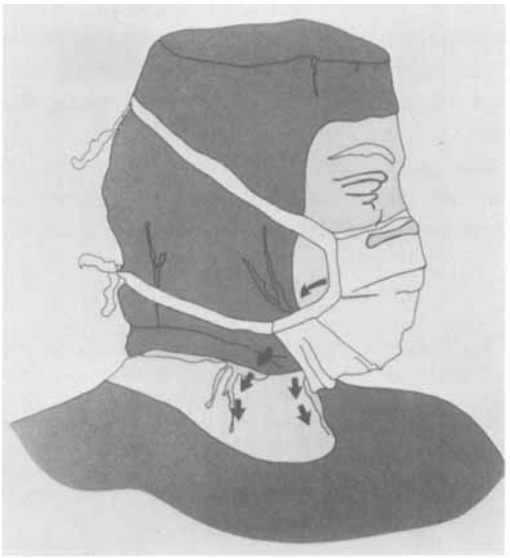

FIG. 1. The nasopharyngeal organisms escaping from beneath the face mask.

FIG. 2. The correct way of wearing face mask. The mask edges are covered by the head gear.

EXPERIMENTS

Human albumin microspheres were applied as previously described to the inner aspect of a surgeon's face mask before 20 major orthopedic procedures. The average operating time was 2 hours. At the conclusion of the operation, prior to wound closure, a standard volume of physiologic saline was used to irrigate the patient's wound and irrigates were collected. The irrigates were centrifuged, and the erythrocytes in the sediment were hemolysed by the addition of distilled water. After washing and repeat spinning, smears were prepared and stained by albumin-specific stains (HABA dye and Bromo Cresol Green) for an easier identification. In addition, the exterior of the face masks was examined under the microscope to assess its filtration efficiency against the particles.

RESULTS

Microspheres were retrieved from the wounds in all 20 experiments, thereby demonstrating wound contamination by the particles.

On microscopy, no microspheres were seen on the exterior of the mask in any of the experiments.

It was possible to quantitate the extent of wound contamination by particle count in microscopic field. The number of particles increased directly with the length of the procedure.

In an attempt to prevent the escape of respiratory organisms from the bottom edge of the face mask and to eliminate this route of wound contamination, the surgical staff started to wear their face masks beneath the headgear so that the mask edges were covered (Fig. 2).

Before 10 further operations, human albumin microspheres were applied to the masks worn as described above. The microspheres were applied in the same manner as in the previous experiments. At the termination of the operations, we were unable to find the microspheres in the wound irrigates in any of the 10 experiments. This demonstrated the advantage of wearing face masks beneath the headgear as described above, rather than in the conventional way.

DISCUSSION

Members of the surgical team may carry virulent bacteria in their nasal and oral cavities. With reports showing that as many as 40% of the surgical team may carry *Staphylococcus aureus* in their nasal and oral cavities,[3,7] the importance of eliminating this route of contamination is clear.

The conventionally used disposable face masks made of soft synthetic fibers have been

proven to be an effective barrier against penetration by bacteria. This was confirmed by our study since no transmission of human albumin microspheres occurred through the mask material, and no particles were identified on the outer surface of the face mask. Therefore, the particles retrieved from the surgical wounds must have passed around the edges of the face masks. Thus, standard face masks appear to be ineffective in preventing this open route of infection.

Covering the edges of the mask with the facial surface of a "bonnet" type of headgear protects only the wound from contamination by respiratory organisms. Bacterial shedding from the forehead and the uncovered part of the surgeon's face still remains a potential source of contamination.[1,9] Thus, there would seem to be justification for surgeons to wear totally enclosed operating suits in order to exclude completely wound contamination from the surgeon's body and upper respiratory tract.

SUMMARY

To examine the efficacy of currently used synthetic-fiber disposable face masks in protecting wounds from contamination, human albumin microspheres were employed as "tracer particles," and applied to the interior of the face mask during 20 operations. At the termination of each operation, wound irrigates were examined under the microscope. Particle contamination of the wound was demonstrated in all experiments. Since the microspheres were not identified on the exterior of these face masks, they must have escaped around the mask edges and found their way into the wound. The wearing of the mask beneath the headgear curtails this route of contamination.

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